Network Working Group
Request for Comments #100
NIC #5761

P. M. Karp
MITRE
26 February 1971

Categorization and Guide to NWG/RFCs

The NWG/RFC Guide is an attempt to introduce some order into the NWG/RFC series, which now numbers 102. The Guide categorizes the NWG/RFC notes, identifies topics under discussion and the relevant NWG/RFCs, and indicates whether the notes are current, obsolete, or superseded.

A minimum subset of NWG/RFCs is identified. This subset consists of the NWG/RFCs that one should read to quickly become familiar with the current status of topics.

For historical reasons and for readers interested in tracing through the stages of development of a topic, a brief summary is given for each NWG/RFC relevant to a particular category.

This initial Guide is being issued as a NWG/RFC since it establishes the basis for future releases. So, please comment! Suggestions, criticism, corrections, etc., will be accepted for a period of approximately two weeks. Be critical as I have not had to implement an NCP and probably have some misconceptions regarding various technical points. An official version will be released on March 26. The Guide will then be a unique series of documents, separate from NWG/RFCs (as is the Document No. 1, No. 2 series).

With regard to renumbering NWG/RFCs, I am inclined to keep the sequential numbering scheme presently employed. The main reason for this position is that the current numbers have both historical and semantic significance. For example, reference to "#33, #66, #83, etc." is a convenient shorthand (reminiscent of the old corny joke about joke #s)

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used extensively during meetings. The list of "current status" NWG/RFC numbers should dispel any fear of maintaining stacks of NWG/RFCs for quick reference. The subject is not closed, however, and I will entertain any objections, suggestions, etc.

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GUIDE TO NETWORK WORKING GROUP/REQUEST FOR COMMENTS

The NWG/RFC notes are partitioned into 9 categories, which in turn are divided into subcategories. For each category the official document (if any), unresolved issues, and documents to be published are identified. For each subcategory, relevant NWG/RFCs are listed and a brief description of the topics addressed in each note is given.

The categories are again listed and the current NWG/RFCs identified (p. 30). The NWG/RFCs in the list comprise the subset defining "current status". Note that most of the documentation in the subset addresses topics in Category D - Subsystem Level Protocol, where at the present time most issues are unresolved.

Finally, the NWG/RFCs are listed by number, with a reference to the relevant categories (p. 33).

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A. ADMINISTRATIVE

A.1 Distribution list

NWG/RFC #s: 3, 10, 16, 24, 27, 30, 37, 52, 69, 95

The distribution list contains names, addresses, and phone numbers for recipients of NWG/RFCs. The most recent list, NWG/RFC 95, designates the Technical Liason as the recipient for each site and supersedes all other RFCs in this category.

A.2 Meeting announcements

NWG/RFC #s: 35, 43, 45, 54, 75, 85, 87, 99

General network working group meetings are held approximately every three months. Special subcommittee meetings are held on an ad hoc basis. All related NWG/RFCs are obsolete except 87, announcing a graphics meeting to be held at MIT in April and 99, announcing a general NWG meeting, Atlantic City, May 16-20.

A.3 Meeting minutes

NWG/RFC #s: 21, 37, 63, 77, 82

The meeting minutes present the highlights of issues discussed at general NWG meetings and report definite decisions that are made.

To be published: A NWG/RFC will be published by Dick Watson, SRI, reporting on the NWG meeting held at the University of Illinois, February 17-19.

A.4 Guide to NWG/RFCs

NWG/RFC #s: 84, 100

The NWG/RFC Guide categorizes the NWG/RFC notes, identifies topics under discussion, the relevant NWG/RFCs, and denotes whether the notes are current, obsolete, or superseded. Included in this category are lists of NWG/RFCs, ordered by number (as in 84) and/or by author.

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A.5 Policies

NWG/RFC #s: 18, 24, 25, 27, 30, 37, 41, 48, 53, 54, 72, 73, 77, 82, 102

NWG/RFCs categorized as policy contain official stands on issues; i.e., the position taken by S. Crocker, NWG Chairman. The issues covered are varied.

In particular:

77 and 82 discuss meeting policy.

72, 73, 77, and 82 discuss the decision to delay making changes to the Host/Host protocol in order to first gain experience with the network. A committee to propose specific changes has been formed.

37 discusses changes to the Host/Host protocol and the schedule for introducing modifications.

53 sets forth the mechanism for establishing and modifying the official Host/Host protocol.

54 presents the initial official protocol.

48 presents some suggestions for policy on some outstanding issues.

41 requests the tagging of IMP-IMP teletype messages.

Documentation conventions for NWG/RFCs are given in 24, 27, and 30.

25 and 18 designate uses for particular link numbers. 25 has been superseded by 37 and 48. 18 is obsolete.

102 discusses the issuing of Document #2, in lieu of the official modification procedure outlined in 53.

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B. HOST/IMP PROTOCOL (LEVEL 1)

Official document: BBN Memo No. 1822 (latest revision - February 1971)

Unresolved issues: Location of first byte of data in a message.

To be published: Document No. 2 will be written by S. Crocker and will, among other things, resolve the first byte location issue.

B.1 General Topics

NWG/RFC #s: 17, 17a, 19, 21, 33, 36, 37, 38, 46, 47, 102

In particular:

17 raised several questions regarding Host/IMP protocol. In 17a, BBN responds to the questions.

19 proposes that the hosts control the ordering of IMP/Host traffic rather than getting messages delivered in the order received by the IMP. This proposal is counter to BBN's position, specifically expressed in 47; that is, buffering is a Host rather than an IMP function. The purpose of buffering in the IMP is to handle surges of traffic, thus IMP buffers should be empty. NWG/RFC 19 is obsolete.

21 discusses changes to BBN Memo No. 1822. The remarks are obsolete.

33 contains a general description of the interface between a host and the IMP. NWG/RFC 47 comments on NWG/RFC 33.

The use of RFNMs (type 10 and type 5 messages) to control flow is discussed in NWG/RFCs 36, 37, and 46. The official position on "cease on link" (i.e., discontinue the mechanism) is presented in 102 and renders obsolete the remarks in 36, 37, and 46.

38 discusses the changes to message format that would be necessary if multiplexing connections over links was allowed.

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B.2 Marking/Padding

NWG/RFC #s: 44, 48, 49, 50, 54, 64, 65, 67, 70, 102

In particular:

102 presents the decision of the Host/Host protocol committee to abandon the marking convention and to ignore padding. The issue of whether to have the first data byte begin after 72 bits of header or to use double physical transmission (NWG/RFC #s 65, 67) is discussed.

The former official position is expressed in 54: "All regular messages consist of a 32 bit leader, marking, text, and padding. Marking is a (possibly null) sequence of zeros followed by a 1; padding is a 1 followed by a (possibly null) sequence of zeros."

Several proposals to eliminate marking have been made. 64 suggests a hardware modification to eliminate marking/padding by adding appropriate counters to Host/IMP interfaces. 65 suggests breaking regular messages into two messages. 67 supports 65. 72 and 73 suggest that such changes be postponed until sufficient experience with the network is gained.

44 introduces the notion of double padding and presents two alternative approaches when a message does not end on a Host word boundary:

a) The host provides padding in addition to the IMPS ("double padding")

b) The host shifts messages to end on a word boundary.

48 explains double padding in more detail and discusses the pros and cons. A suggestion is made to use marking to adjust the word boundary (alternative b). NWG/RFCs 49 and 50 are concurrences with 48.

70 presents a method to handle the stripping of padding from a message.

All NWG/RFCs in this category have been superseded by 102.

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C. HOST/HOST PROTOCOL (LEVEL 2)

Host/Host protocol specifies the procedures by which connections for inter-Host interprocess communication over the network are established, maintained, and terminated. The software which implements the protocol within each Host is called the Network Control Program (NCP). The topics included in this category are connection establishment and termination, flow control, interrupt handling, error control and status testing, dynamic reconnection, and the relationship between connections and links.

Official documents: Document No. 1 by S. Crocker, 3 August 1970, with modifications presented in NWG/RFC 102.

Unresolved issues: Length of control messages
Location in message of first byte of data
Flow control algorithm
Socket identification format

To be published: Document No. 2 will be written by S. Crocker and will resolve the first three issues. A NWG/RFC will be written by J. Heafner, in collaboration with E. Meyer and G. Grossman, presenting the pros and cons on alternative proposals for socket number identification.

C.1 Host/Host Protocol Proposals

NWG/RFC #s: 9, 11, 22, 33, 36, 37, 38, 39, 40, 44, 46, 48, 49, 50, 54, 57, 59, 60, 61, 62, 65, 68, 93, 102

The official Host/Host protocol presented in Document No. 1 is based on the proposals, discussions, acceptance, and rejection of ideas in the above list of NWG/RFCs, up to and including 59.

In particular:

9, 11, and 22 represent an early attempt at a Host/Host protocol. 11 supersedes 9 and 22 contains some modifications to control message formats presented in 11. The protocol was not considered powerful enough because it didn't provide for inter-host communication without logging in. This protocol was thrown out as a result of a network meeting in December 1969.

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33 is the basis for the current protocol. It was presented at the SJCC, 1970.

36 is a modification of 33. It disucsses connection establishment without switching, flow control, and introduces the idea of re-connection. Control commands are summarized. 36 was distributed at a Network meeting in March 1970.

37 presents the reaction to 36 and presents ideas on reconnection flow control and decoupling of links and connections. Provisions for error detection, status testing, experimentation and expansions are discussed.

38, 39, 40, 44, 49, and 50 are comments written in response to the meeting. 46 is also a comment but in the form of a rewrite of 33. 46 introduces the notion of interrupts, INT, and ECO for status testing.

47 concerns the philosophy behind the notion of a link.

48 summarizes the issues discussed in the above NWG/RFCs.

54 is the initial official protocol submitted for criticism, comments, etc. It introduces a new mechanism for flow control in which the receiving host allocates buffer space and notifies the sending host of the space available.

57 and 59 comment on 54.

Document No. 1 differs from NWG/RFC 54 as follows: commands GVB and RET have been added for flow control and error condition codes have been added to ERR. NWG/RFC 102 presents some modifications to Document No. 1: fixed lengths are specified for ECO, ERP, and ERR; a new pair of commands RST and RRP (suggested in 57) are added.

60, 61, and 62 propose new Host/Host protocols, quite different from the current official protocol. 62 supersedes 61. 60 and 62 are worth considering for possible implementation in future protocols. Hopefully, more documents of a similar nature will be generated as experience is gained with the current protocol.

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NWG/RFCs 65 and 68 comment on Document No. 1.

93 points out an ambiguity in Document No. 1 regarding the requirement of a message data type in the message sent from server socket 1. The ambiguity is resolved by 102 which eliminates message data type from level 2 protocol.

C.2 NCPs (Description, Structure, Techniques)

NWG/RFC #s: 9, 11, 22, 23, 33, 36, 44, 46, 48, 55, 70, 71, 74, 89

This category includes RFCs which give details of system calls, table structures, implementation techniques, etc.

In particular:

NWG/RFCs 9, 11, and 22 are obsolete

23 is a general statement on sending or receiving multiple control messages in a single communication.

33 discusses the system calls used for interaction between the NCP and a user process.

36 describes a possible implementation giving table structures and their interrelationships.

44 lists the system calls that SDC feels should operate, includes spec. of calls to NCP.

NWG/RFC 48 presents Postel's and Crocker's view on the environment in which a host time-sharing system operates, suggests some system calls, and presents a design to illustrate the components of an NCP.

55 presents a prototypal NCP which implements the initial official protocol specified in 54. It is offered as an illustrative example.

70 gives some techniques for stripping the padding from a message.

71 presents the method employed by the CCN-Host at UCLA to re-synchronize flow control when an input error occurs.

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74 documents the implementation of sections of the NCP at UCSB.

89 gives a brief description of the "interim interim NCP" (IINCP) on the MIT Dynamic Modeling PDP-6/10 used to run some experiments.

C.3 Connection Establishment and Termination

NWG/RFC #s: 33, 36, 39, 44, 49, 50, 54, 60, 62

The NWG/RFCs in this cateogry present che system calls and control commands used to establish and terminate connections, i.e., the handshaking that must transpire before connections are established or terminated.

In particular:

36 presents a rough scenario of connection establishment which differs from that specified in 33 in that establishment does not include procedures for switching procedures.

39 suggests the addition of a command TER to supplement CLS.

44 discusses the use of the CLS command and suggests that two commands BLK and CLS be adopted.

46, 49, and 50 all discuss queuing of RCFs.

54 presents the initial official method for establishing and terminating connections.

60 and 62 present schemes different from the official protocol.

C.4 Flow Control

NWG/RFC #s: 19, 33, 36, 37, 46, 47, 54, 59, 60, 65, 68, 102

The NWG/RFCs in this category address the problem of controlling the flow of messages from the sending socket to the receive socket. The official position is stated in Document No. 1 with an unresolved issue pending as described in NWG/RFC 102.

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In particular:

19 suggests that Hosts may want the capability of agreeing to lock programs into core for more efficient core-to-core transfers. This may require different handling of RFNMs.

33 describes the use of RFNM (type 10 rather than 5) on a link to control flow. A control command RSM (resume) is defined to allow the host to signal for resumption of message flow. 46 describes the same technique.

37 describes the effect some proposed changes (for reconnect and decoupling of connections and links) would have on RFNMs and "cease on link."

46 (MIT's rewrite of protocol) introduces BLK and RSM commands as an alternative to "cease on link", SPD and RSM commands.

47 presents BBN's position that buffering be handled by the Host, not the IMP.

54 introduces a new flow control mechanism in which the receiving host is required to allocate buffer space for each connection and to notify the sending host of bit sizes. A new command, ALL to allocate space is sent from the receiving host to the sending host. With this new mechanism, 33, 37, 46, and 47 become obsolete.

59 presents the objections of Project MAC and Lincoln Labs to the flow control mechanism introduced in 54. Their preference is for "cease on link" which allocates buffer space on demand.

60, which defines a simplified NCP protocol, presents a method of flow control based on the requirement that connections are full-duplex.

65 comments on Document No. 1. With respect to flow control, it disagrees with the allocation mechanism and the introduction of irregular message to make the cease mechanism work.

68 proposes modifications to RFNM by defining three forms which would insure control of data and would replace the memory allocation mechanism.

102 eliminates the cease mechanism and introduces potential modifications to the flow control mechanism. The latter will be resolved and presented in Document No. 2.

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C.5 Error Control and Status Testing

NWG/RFC #s: 2, 37, 39, 40, 46, 48, 54, 57, 102

This category addresses schemes for detecting and controlling errors and for Host status reporting and testing.

In particular:

2 talks about error checking and gives an algorithm for implementing a checksum. It also recommends that Hosts should have a mode in which positive verification of all messages is required.

37 brings up the topics of error detection and status testing, which are expanded by RAND in 39 and 40. 39 introduces control commands ERR for error checking and QRY, HCU, and HGD for status testing. 40 expands on the discussion, suggests error codes, introduces RPY as a response to QRY, and suggests that NOP could be used for reporting Host status.

46 concurs with 40 on ERR and introduces ECO to test communication between NCPs.

48 recommends that ERR, as presented in 40 and 46, be adopted, that a distinction be made between resource errors and other error types, that ECO, presented in 46, be of variable length, and that an ECO, ERP command pair be adopted.

54 officially specifies the control commands ERR, ECO, and ERP. The official protocol doesn't include a specific list of error types nor does it recommend the action to be taken. Suggestions for extensions to error detection and recovery and Host/Host status testing are encouraged.

57 presents a list of error types and suggests new commands OVF for overflow errors and RST/RSR for host status testing.

102 sets fixed lengths for ERR, ECO, and ERP control commands. RST and RSR are adopted.

C.6 Interrupt

NWG/RFC #s: 46, 48, 49, 50, 54, 102

The interrupt system call and the INT control commands are used to interrupt a process. This is actually a third level issue. The NWG/RFCs leading up to the decision to include INR and INS in the official protocol are summarized below.

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In particular:

46 introduces the INT command as a method for interrupting a process.

48 recommends adoption of INT with the restriction that the feature should not be used during communication with systems which scan for interrupts and that INT should not be used on non-console type connections (see D.2).

49 expands on the explanation of INT. 50 concurs with proposal 46, that INT is useful.

54 induces INR, INS control commands in the official protocol as an escape mechanism, where interpretation is a local matter.

102 discusses synchronization of interrupt signals, presents two implementation schemes, and relegates the topic to third level protocol. INS should be used to indicate a special code in the input stream.

C.7 Dynamic Reconnection

NWG/RFC #s: 33, 36, 37, 38, 39, 44, 46, 48, 49, 50

The notion of dynamic reconnection was introduced early in the Host/Host protocol design. However, the consensus was that it introduced complexities with which the initial NCP implementations did not want to cope. The need for dynamic reconnection was questioned; NWG/RFC 48 explains why it was included and considered useful.

In particular:

33 introduces the concept of switching connections to the Logger.
36 presents a scheme for dynamic reconnection, i.e., reconnection can take place after the flow is started.

37 presents two methods suggested by BBN for handling reconnection.

38 discusses changes to proposed END and RDY control commands that would be necessary if connections were multiplexed over links.

39 states that dynamic reconnection is too complex.

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44 presents two cases where reconnection could be used, suggests that the cases be separated, and recommends implementation of only the case of a simple connection switch within the same Host.

46 recommends that dynamic reconnection be reserved for further Host/Host protocol implementations.

48 discusses the aesthetics of dynamic reconnection in detail but concedes that it won't be included in the initial protocol. 49 and 50 concur with the decision.

C.8 Relation Between Connections and Links

NWG/RFC #s: 37, 38, 44, 48

A connection is an extension of a link. The NWG/RFCs in this category discuss this relationship.

In particular:

37 presents the pros and cons on decoupling connections and links.

38 recommends that connections be multiplexed over links. Two cases where this would be useful are presented. The effect on the proposed protocol is discussed. Both 37 and 38 suggest the inclusion of the destination socket as part of the text of the message and recommend that messages should be send over any unblocked link.

44 suggests the use of link numbers in control commands (except RFSs) due to the 1 to 1 correspondence between links and foreign socket numbers.

48 recommends leaving links and connections coupled.

C.9 Other

Other topics that fall into the category of Host/Host protocol are:

Marking/Padding: see B.2

Record/Message Boundaries: see D.5

Experimentation and Expansion: The assignment of links for experimentation and expansion is discussed in NWG/RFC #s 37 and 48.

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Instance Tag: The addition of an instance tag to the socket identifier is introduced in 46, is supported by 49 and 50, and is not recommended in 48. The matter is unresolved (see "To be published", section C).

Broadcast Facility: A control command to implement a broadcast facility was introduced in 39. It was not supported in 48.

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D. SUBSYSTEM LEVEL PROTOCOL (LEVEL 3)

Official document: none

Unresolved issues: all

To be published: Three committees have been set up to address user level issues, specifically: logger, console, and TELNET protocols (D.1, D.2, D.3); data transformation (D.4); and, graphics protocol (D.6). Status reports will be published prior to the next Network meeting (May 1971). In addition, a companion paper to 98 discussing console protocol has been promised by MIT MAC and G. Grossman (Ill.) will issue an RFC proposing a file transmission protocol.

D.1 Logger Protocol

NWG/RFC #s: 33, 46, 48, 49, 50, 56, 66, 74, 77, 79, 82, 88, 91, 93, 97, 98

Logger protocol specifies the procedures by which a user gets connected to a remote Host. The logger is a process, always in execution, which listens for login requests.

In particular:

33 proposes that the logger listen to calls on socket #0. It then switches to the assigned socket. The sequence of events is illustrated.

46 proposes a User Control and Communication (UCC) module, which implements logger protocol, and permits the logger to interact with the NCP. It proposes the use of two full-duplex pseudo-typewriter connections.

48 proposes that sockets <U, H, 0> and <U, H, 1> designate either the input and output sockets of a copy of the logger or the console sockets.

49 is a write-up of a combination of the proposals presented in 46 and 48. 49 presents the disadvantages of the new proposal and reverts back to supporting the UCC of 46.

50 indicates RAND support for the UCC presented in 46.

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56 defines a send-logger and a receive-logger with a full-duplex connection. The logger handles one request at a time; requests are queued. The receiver logger is identified as user 0 on socket 0.

66 introduces a dial-up protocol (Initial Connection Protocol, ICP) to get a process at one site in contact with the logger at another site.

74 documents the logger implemented at UCSB.

77 and 82 report the discussion of logger protocol at the FJCC 1970 Network meeting. E. Harslem and E. Meyer agreed to write proposals.

79 discusses a conflict between Document No. 1 and NWG/RFC 66 regarding the use of ALL prior to connection establishment. 80 presents a variation of 66 that rectifies the conflict. 80 also suggests that ICP should apply to more than just the logger; i.e., let user 0 signify the logger.

88 documents the logger implemented as part of NETRJS, which allows access to RJS at UCLA's CCN. The ICP described in 66 and 80 is adhered to. The logger is designated as user 0.

91 contains a description of the logger for the PDP-10 at Harvard.

93 points out an ambiguity in the Host/Host protocol of Document No. 1 regarding the requirement of message data type for ICP. The ambiguity is rectified by NWG/RFC 102.

97 includes the ICP (as proposed in 80) used to establish connection to NIC.

98 is the logger protocol proposal issued by E. Meyer.

D.2 Console Protocol

NWG/RFC #s: 20, 44, 46, 48, 49, 50, 56, 66, 74, 77, 82, 88, 91, 96, 97, 98

Console protocol will specify conventions for what goes out over the network. Included are conventions for echoing, character set, interrupt or break, end of line, message formats.

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In particular:

20 suggests a standard of 7-bit ASCII in an 8-bit byte, with the high order bit 0.

44 discusses three possibilities for echoing over the network (echoing, no echoing, optional echoing) and states a preference for no echoing. 44 also states a preference for establishing a network common code where all code conversion is performed on outgoing text; thus, all incoming text would be in the common code.

46 proposes the use of interrupt on the third level. An interrupt means "quit" when sent from a requestor process to a created process. The command level is entered.

48 and 49 relegate issues of echoing and code conversion to third level protocol.

50 and 56 support adoption of ASCII for the network standard character set. 56 also discusses two uses of break characters (interrupt): in a panic situation and to exit from a subsystem. Three message formats (character by character, end by carriage return, several command lines per message) are discussed. A recommendation that echoing be handled locally is made.

66 specifies that the standard console use 7-bit ASCII in 8 bits with the 8th bit on (note the conflict with 20). It also specifies the use of INR for break or interrupt.

74 documents console protocol implemented by UCSB.

77 and 82 report on console protocol topics (echoing, full vs half duplex) discussed at the Network meeting, FJCC 1970.

88 documents conventions used by NETRJS for RJS at CCN, UCLA.

91 discusses code standards.

96 and 97 document conventions used for NIC at SRI ARC.

98 proposes specifications for general console communications and addresses full vs half duplex, character escapes, and action characters.

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D.3 TELNET Protocol

NWG/RFC #s: 15, 33, 76, 80, 83, 91, 96, 97

TELNET is a subsystem permitting a teletype-like terminal at a remote Host to function as a teletype at the serving Host. TELNET protocol specifies user level interface to the network by way of network system calls.

In particular:

15 introduces the TELNET concept and presents a sample dialogue between Utah's PDP-10 and SRI's 940. System primitives are proposed.

33 describes TELNET and gives essentially the same example as in 15.

76 describes a terminal user control language for Illinois's PDP-11 ARPA Network Terminal System. The protocol defined permits the user to utilize the network at a symbolic level.

80 and 83 introduce the concept of a Protocol Manager that can manage protocol sequences between consoles and the network. The Form Machine (see D.4) can be used for translations.

91 contains a proposal for a User/User protocol that has the ability to function as TELNET.

96 describes a series of experiments to be conducted using the TELNET subsystem at SRI ARC.

97 presents a detailed proposal for a standard TELNET protocol.

D.4 NIL, DEL, and Form Machines

NWG/RFC #s: 5, 31, 42, 51, 63, 80, 83, 96

NIL, DEL, and Form Machines are proposals of similar methods for adapting user programs and/or data to the network. A committee chaired by J. Heafner has been formed to plan, implement, and exercise a language for reconfiguring data streams.

In particular:

NIL (Network Interchange Language), described in 51, introduces the concept of an abstract network machine which would permit a user to consider the computer network as an overall computing facility. All dialogue would take place between hosts and

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the network machine. NIL permits the description of the environment and the description of the Front End of an interactive system. Sublanguages for describing control, operation, data declaration, and environment are used. With NIL, the network machine can operate in standard mode as well as user-defined extended mode. The network machine can act as a user of a Host; conversely, a Host can be a user of a network machine. Each Host will have a generator to generate a translator from the descriptive sublanguage inputs.

DEL (Decode - Encode Language), described in 5, utilizes a front end translator at the using site to translate the using site characters to the server host character set. Return messages are subsequently translated locally to the local standard. Immediate feedback in an interactive mode is also handled locally. DEL can be used for the operation of large display-oriented systems. Provisions are given for representing a universal hardware. The syntax is included.

Two proposals for the Form Machine have been given. 80 introduces the concept of the Form Machine, an experimental software package operating on regular expressions that describe data formats. 83 presents a different approach: a syntax-driven interpreter which operates on a grammar which is an ordered set of replacement rules. 83 contains a description of the Form Machine with some examples of replacement rules for particular data types. Application of the Form-Machine to program protocols is also discussed.

31 proposes a message description language as a standard symbolic method for defining and describing binary messages. In the future, the descriptive language could be used as input to generators of data translation programs.

42 proposes the use of message data types prior to the development of network languages specifying the syntax and semantics of messages. Programs would extract the message data type and transform the data accordingly. Both standard and local types would be handled (as in RFC #51), probably using tables stored at one location such as NIC. 62 presents data type codes.

96 includes a discussion on a Front End for NLS (T) and suggests that further study be given to standard languages as presented in 51.

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D.5 Record/Message Boundaries

NWG/RFC #s: 13, 49, 50, 58, 63, 77, 82, 91

Positions that no special structures should be imposed on data transmission are presented in 49 and 91. 50 and 58 disagree. 58 claims that logical and physical message distinctions exist and that logical messages must begin on a physical message boundary.

63 reports a decision from a meeting that records may begin anywhere in a message. In a later meeting, 77 and 82, the issue was reopened. Discussion included consideration of methods of indicating the end of message and alternatives were given. Earlier RCFs had discussed these alternatives: 13 proposes a 0 length message to specify EOF; 50 proposes use of a bit count preceding the transmission and discusses solutions to the problem of dropping bits.

D.6 Network Graphics

NWG/RFC #s: 43, 77, 80, 82, 86, 87, 89, 94

Proposals specifying network graphics protocol are in the formative stages.

In particular:

43 mentions LIL, an interpretable language at Lincoln Labs that can handle interactive graphics.

77 and 82 discuss the formation of a working group to specify procedures for using graphics over the network.

80 states that graphics oriented descriptions will be added to the Form Machine.

86 is a proposal for a network standard format for a data stream to control graphics displays. 87 announces a network graphics meeting to be hosted by MIT and suggests discussion topics. Both 86 and 87 are attempts to stimulate some interest in the generation of graphics protocol proposals.

89 describes a Harvard-MIT graphics experiment using the network.

94 comments on 86 and presents an alternate proposal.

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D.7 File Transmission

NWG/RFC #s: 13, 38, 77, 82, 91

The subject of file transmission over the network is at the informal discussion stage. Nothing substantive has been published as NWG/RFCs in this category.

In particular:

13 proposes using a 0 length message to specify EOF.

38 recommends routing multiple connections over the same link to handle file transmissions over the network.

77 and 82 summarize comments on file transmission problems aired at the Network meeting in Houston, Nov. 1970.

91 describes how PDP-10 file transmission could be handled over the network.

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E. MEASUREMENT ON NETWORK

Official document: none

Unresolved issues: Should NCPs be altered to keep measurement statistics?

E.1 General

NWG/RFC #s: 77, 82

Both 77 and 82 report on the comments made at the Network meeting, Houston 1970, regarding network measurements. UCLA and BBN are officially responsible for gathering network statistics. Is it reasonable to alter the NCP to keep statistics?

E.2 Clock

NWG/RFC #s: 28, 29, 32, 34

The NWG/RFCs in this category discuss requirements for a clock to measure network delay.

In particular:

28 is concerned with the installation of a real-time clock at SRI ARC and requests comments concerning network time standards for delay measurement.

29 responds to 28, stating that a millisecond clock should be sufficient.

32 discusses the desirability of adding a network clock for measurement of user-oriented message delays. A one millisecond resolution is a reasonable specification. The problems of clock synchronization and long term accuracy are addressed.

34 describes the SRI ARC clock on the XDS 940.

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F. NETWORK EXPERIENCE

NWG/RFC #s: 78, 89

Reports on experience with the network are starting to be published. As sites begin to get their NCPs up, more notes in this category should be generated and are encouraged.

In particular:

78 describes NCP checkout between UCSB and RAND.

89 describes initial activity on the network between MIT MAC Dynamic Modeling/Computer Graphics PDP-6/10 System and the Harvard PDP-10.

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G. SITE DOCUMENTATION

Official document: None

Unresolved issues: Procedures for entering documentation at NIC.

To be published: Dick Watson, SRI ARC, will publish documentation specifications and procedures.

G.1 General

NWG/RFC #s: 77, 82

77 and 82 contain general comments on storing system documentation on-line.

G.2 NIC

NWG/RFC #s: 77, 82, 96, 97

77 and 82 contain summaries of Engelbart's discussion of NIC at the Network meeting in Houston, November, 1970.

96 and 97 contain details of third level protocol implementation for NLS (NIC).

G.3 UCSB

NWG/RFC #s: 74

74 presents specifications for network use of the UCSB On-Line System (OLS).

G.4 CCN (UCLA)

NWG/RFC #s: 88, 90

88 describes the protocol implementation for RJE.

90 specifies the resources available at CCN, operating as a Network Service Center.

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G.5 University of Illinois

NWG/RFC #s: 76

76 describes the PDP-11 ARPA Network Terminal System implementation.

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H. ACCOUNTING

To be published: B. Kahn, BBN, will generate an RFC discussing important considerations for an accounting mechanism.

NWG.RFC #s: 77, 82

This topic will be addressed by the long-range Host/Host protocol committee, set up at the Network meeting, University of Illinois, February 1971.

77 and 82 discuss the need for some network accounting scheme, primarily for sites classified as Service Centers rather than Research Centers.

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I. OTHER

The topics grouped in this catch-all category may in the future constitute independent categories.

I.1 Hardware

NWG/RFC #s: 12, 64

12 contains diagrams that indicate the logical sequence of hardware operations which occur within the IMP/Host interface.

64 proposes a hardware solution to getting rid of marking. 64 has been superseded by 102.

I.2 Request for References

NWG/RFC #s: 81

81 requests references concerning communications.

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Issues and Current NWG/RFCs

Subset reflecting current status:

NWG/RFC #s: 5, 12, 30-33, 41, 47, 48, 51, 53-56, 60, 62, 66, 74, 76-78, 80-83, 86-91, 94-100, 102

A. ADMINISTRATIVE

A.1 Distribution List
NWG/RFC #s: 95

A.2 Meeting Announcements
NWG/RFC #s: 87, 99

A.3 Meeting Minutes
NWG/RFC #s: 77, 82

A.4 Guide to NWG/RFCs
NWG/RFC #s: 100

A.5 Policies
NWG/RFC #s: 30, 41, 53, 77, 82, 102

B. HOST/IMP PROTOCOL

Official document: BBN Memo No. 1822

B.1 General
NWG/RFC #s: 33, 47, 102

B.2 Marking/Padding
NWG/RFC #s: 102

C. HOST/HOST PROTOCOL

Official document: Document No. 1, S. Crocker, 3 August 1970

C.1 Host/Host Protocol Proposals
NWG/RFC #s: 33, 48, 54, 60, 62, 102

C.2 NCPs (Description, Structure, Techniques)
NWG/RFC #s: 55, 74

C.3 Connection Establishment and Termination
NWG/RFC #s: 54

C.4 Flow Control
NWG/RFC #s: 54, 102

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C.5 Error Control and Status Testing
NWG/RFC #s: 54, 102

C.6 Interrupt
NWG/RFC #s: 54, 102

C.7 Dynamic Reconnection
NWG/RFC #s: 48

C.8 Relation Between Connections and Links
NWC/RFC #s: 48

D. SUBSYSTEM LEVEL PROTOCOL

D.1 Logger Protocol
NWC/RFC #s: 56, 66, 80, 98

D.2 Console Protocol
NWG/RFC #s: 66, 77, 82, 96, 97, 98

D.3 TELNET Protocol
NWG/RFC #s: 33, 96, 97

D.4 NIL, DEL, Form Machines
NWG/RFC #s: 5, 31, 51, 83

D.5 Record/Message Boundaries
NWG/RFC #s: 77, 82, 91

D.6 Network Graphics
NWG/RFC #s: 86, 87, 94

D.7 File Transmission
NWG/RFC #s: 77, 82, 91

E. MEASUREMENT ON NETWORK

E.1 General
NWG/RFC #s: 77, 82

E.2 Clock
NWG/RFC #s: 32

F. NETWORK EXPERIENCE

NWG/RFC #s: 78, 89

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G. SITE DOCUMENTATION

G.1 General
NWG/RFC #s: 77, 82

G.2 NIC
NWG/RFC #s: 77, 82, 96, 97

G.3 UCSB
NWG/RFC #s: 74

G.4 CCN (UCLA)
NWG/RFC #s: 88, 90

G.5 Illinois
NWG/RFC #s: 76

H. ACCOUNTING

NWG/RFC #s: 77, 82

I. OTHER

I.1 Hardware
NWG/RFC #s: 12

I.2 Request for References
NWG/RFC #s: 81

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List of NWG/RFC #'s 1-102
With Cross-Reference to Catigorized Topics

NWG/RFC 1: HOST Software
S. Crocker (UCLA) 7 April 1969
Obsolete

NWG/RFC 2: HOST Software
B. Duvall (SRI) 9 April 1969
C.5, otherwise obsolete

NWG/RFC 3: Documentation Conventions
S. Crocker (UCLA) 9 April 1969
A.1

NWG/RFC 4: Network Timetable
E. Shapiro (SRI) 24 March 1969
Obsolete

*NWG/RFC 5: DEL
J. Rulifson (SRI) 2 June 1969
D.4

NWG/RFC 6: Conversation with Bob Kahn
S. Crocker (UCLA) 10 April 1969
Obsolete

NWG/RFC 7: HOST/IMP Interface
G. Deloche (UCLA) 5 May 1969
Obsolete

NWG/RFC 8: ARPA Network Functional Specifications
G. Deloche (UCLA) 5 May 1969
Obsolete

NWG/RFC 9: HOST Software
G. Deloche (UCLA) 1 May 1969
C.1 C.2

NWG/RFC 10: Documentation Conventions
S. Crocker 29 July 1969
A.1

* indicates inclusion in the subset of "current issues".

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NWG/RFC 11: Implementation of the HOST-HOST Software Procedures in GORDO
G. Deloche (UCLA) 1 August 1969
C.1 C.2

*NWG/RFC 12: IMP-HOST Interface Flow Diagram
M. Wingfield (UCLA) 26 August 1969
I.1

NWG/RFC 13: Referring to NWG/RFC 11
V. Cerf (UCLA) 20 August 1969
D.5 D.7

NWG/RFC 14: (never issued)

NWG/RFC 15: Network Subsystem for Time-Sharing HOSTS
C. S. Carr (UTAH) 25 September 1969
D.3

NWG/RFC 16: MIT (address)
S. Crocker 27 August 1969
A.1

NWG/RFC 17 & 17a: Some Questions Re: HOST-IMP Protocol
J. E. Kreznar (SDC) 27 August 1969
B.1

NWG/RFC 18: (use of links 1 and 2)
V. Cerf (UCLA) September 1969
A.5

NWG/RFC 19: Two Protocol Suggestions to Reduce Congestion at Swap-bound Nodes
J. E. Kreznar (SDC) 7 October 1969
B.1 C.4

NWG/RFC 20: ASCII Format for Network Interchange
V. Cerf (UCLA) 16 October 1969
D.2

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NWG/RFC 21: (report of Network meeting)
V. Cerf (UCLA) 17 October 1969
A.3 B.1

NWG/RFC 22: HOST-HOST Control Message Formats
V. Cerf (UCLA) 17 October 1969
C.1 C.2

NWG/RFC 23: Transmission of Multiple Control Messages
G. Gregg (UCSB) 16 October 1969
C.2

NWG/RFC 24: Documentation Conventions
S. Crocker (UCLA) 21 November 1969
A.1 A.5

NWG/RFC 25: No High Link Numbers
S. Crocker (UCLA) 30 October 1969
A.5

NWG/RFC 26: (never issued)

NWG/RFC 27: Documentation Conventions
S. Crocker (UCLA) 9 December 1969
A.1 A.5

NWG/RFC 28: Time Standards
B. English (ARC) 13 January 1970
E.1

NWG/RFC 29: Note in Response to Bill English's Request for Comments
R. Kahn (BBN) 19 January 1970
E.1

*NWG/RFC 30: Documentation Conventions
S. Crocker (UCLA) 4 February 1970
A.1 A.5

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*NWG/RFC 31: Binary Message Forms in Computer Networks
D. Bobrow (BBN)
W. R. Sutherland (LINC) February 1968

D.4

*NWG/RFC 32 Connecting M.I.T. Computers to the ARPA Computer-To-Computer Communication Network
D. Vedder (MAC) 31 January 1969

E.1

*NWG/RFC 33: New HOST-HOST Protocol
S. Crocker (UCLA) 12 February 1970

B.1 C.1 C.2 C.3 C.4 C.7 D.1 D.3

NWG/RFC 34: Some Brief Preliminary Notes on the ARC Clock
B. English (ARC) 26 February 1970

E.1

NWG/RFC 35: Network Meeting
S. Crocker (UCLA) 3 March 1970

A.2

NWG/RFC 36: Protocol Notes
S. Crocker (UCLA) 16 March 1970

B.1 C.1 C.2 C.3 C.4 C.7

NWG/RFC 37: Network Meeting Epilogue, etc.
S. Crocker (UCLA) 20 March 1970

A.1 A.3 B.1 C.1 C.4 C.5 C.7 C.8 C.9

NWG/RFC 38: Comments on Network Protocol from NWG/RFC 36
S. M. Wolfe (UCLA) 20 March 1970

B.1 C.1 C.7 C.8 D.7

NWG/RFC 39: Comments on Protocol Re: NWG/RFC 36
E. Harslem (RAND)
J. Heafner (RAND) 25 March 1970

C.1 C.3 C.5 C.7 C.9

NWG/RFC 40: More Comments on the Forthcoming Protocol
E. Harslem (RAND)
J. Heafner (RAND) 27 March 1970

C.1 C.5

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*NWG/RFC 41: IMP-IMP Teletype Communication
J. Melvin (ARC) 30 March 1970
A.5

NWG/RFC 42: Message Data Types
E. I. Ancona (LINC) 31 March 1970
D.4

NWG/RFC 43: Proposed Meeting
A. G. Nemeth (LINC) 8 April 1970
A.2 D.6

NWG/RFC 44: Comments on NWG/RFC 33 and 36
A. Shoshani (SDC)
R. Long (SDC)
A. Landsberg (SDC) 10 April 1970
B.2 C.1 C.2 C.3 C.7 C.8 D.2

NWG/RFC 45: New Protocol is Coming
J. Postel (UCLA)
S. Crocker (UCLA) 14 April 1970
A.2

NWG/RFC 46: ARPA Network Protocol Notes
E. W. Meyer, Jr. (MAC) 17 April 1970
B.1 C.1 C.2 C.3 C.4 C.5 C.6 C.7 D.1

*NWG/RFC 47: BBN's Comments on NWG/RFC 33
J. Postel (UCLA)
S. Crocker (UCLA) 20 April 1970
B.1 C.4

*NWG/RFC 48: A Possible Protocol Plateau
J. Postel (UCLA)
S. Crocker (UCLA) 21 April 1970
A.5 B.2 C.1 C.2 C.5 C.6 C.7 C.8 C.9 D.1 D.2

NWG/RFC 49: Conversations with Steve Crocker
E. W. Meyer, Jr. (MAC) 25 April 1970
B.2 C.1 C.3 C.6 C.7 C.9 D.1 D.2 D.5

NWG/RFC 50: Comments on the Meyer Proposal
E. Harslem (RAND)
J. Heafner (RAND) 30 April 1970
B.2 C.1 C.3 C.6 C.7 C.9 D.1 D.2 D.5

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*NWG/RFC 51: Proposal for a Network Interchange Language
M. Elie (UCLA) 4 May 1970

D.4

NWG/RFC 52: Updated Distribution List
S. Crocker, J. Postel (UCLA) 1 July 1970

A.1

*NWG/RFC 53: An Official Protocol Mechanism
S. Crocker (UCLA) 9 June 1970

A.5

*NWG/RFC 54: An Official Protocol Proffering
S. Crocker et al (UCLA) 18 June 1970

A.2 A.5 B.2 C.1 C.3 C.4 C.5 C.6

*NWG/RFC 55: A Prototypical Implementation of the NCP
J. Newkirk, et al (HARV) 19 June 1970

C.2

*NWG/RFC 56: Third Level Protocol
E. Belove, et al (HARV) 19 June 1970

D.1 D.2

NWG/RFC 57: Thoughts and Reflections on NWG/RFC 54
M. Kraley, J. Newkirk (HARV) 19 June 1970

C.1 C.5

NWG/RFC 58: Logical Message Synchronization
T. P. Skinner (MAC) 26 June 1970

D.5

NWG/RFC 59: Flow Control - Fixed Versus Demand Allocation
E. W. Meyer, Jr. 27 June 1970

C.1 C.4

*NWG/RFC 60: A Simplified NCP Protocol
R. Kalin (LINC) 13 July 1970

C.1 C.3 C.4

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NWG/RFC 61: A Note on Interprocess Communications in a Resource Sharing Computer Network
D. Walden (BBN) 17 July 1970

superseded by 62

*NWG/RFC 62: A Note on Interprocess Communication in a Resource Sharing Computer Network
D. Walden (BBN) 3 August 1971

C.1 C.3

NWG/RFC 63: Belated Network Meeting Report
V. Cerf (UCLA) 31 July 1970

A.3 D.4 D.5

NWG/RFC 64: Getting Rid of Marking
M. Elie (undated)

B.2 H.2

NWG/RFC 65: Comments on Host-Host Protocol Document No. 1 (by S. Crocker - 8/3/70)
D. Walden (BBN) 29 August 1970

B.2 C.1 C.4

*NWG/RFC 66: 3rd Level Ideas and Other Noise
S. Crocker (UCLA) 26 August 1970

D.1 D.2

NWG/RFC 67: Proposed Change to Host/IMP Spec to Eliminate Marking
W. Crowther (BBN) (undated)

B.2

NWG/RFC 68: Comments on Memory Allocation Control Commands (CEASE, ALL, GVB, RET) and RFNM
M. Elie (UCLA) 31 August 1970

C.1

NWG/RFC 69: Distribution List Change for MIT
A. Bhushan (MAC) 22 September 1970

A.1

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NWG/RFC 70: A Note on Padding
S. Crocker (UCLA) 15 October 1970

B.2 C.2

NWG/RFC 71: Reallocation in Case of Input Error
T. Schipper (UCLA) 25 September 1970

C.2

NWG/RFC 72: Proposed Moratorium on Changes to Network Protocol
R. D. Bressler (MAC) 28 September 1970

A.5

NWG/RFC 73: Response to NWG/RFC 67
S. Crocker (UCLA) 25 September 1970

A.5

*NWG/RFC 74: Specifications for Network Use of the UCSB On-Line Systems
J. White 16 October 1970

D.1 D.2 G.3

NWG/RFC 75: Network Meeting
S. Crocker (UCLA) 14 October 1970

A.2

* NWG/RFC 76: Connection-By-Name: User-Oriented Protocol
J. Bouknight et al., (ILL) 28 October 1970

D.3 G.5

*NWG/RFC 77: Network Meeting Report
J. Postel (UCLA) 20 November 1970

A.3 A.5 D.1 D.2 D.5 D.6 D.7 E.1 G.1 G.2 H

*NWG/RFC 78: NCP Status Report: UCSB/RAND
E. Harslem et al., (RAND) (undated)

F

NWG/RFC 79: Logger Protocol Error
E. W. Meyer, Jr. (MAC) 16 November 1970

D.1

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*NWG/RFC 80: Protocols and Data Formats
E. Harslem et al., (RAND) 1 December 1970

D.3 D.4 D.6

*NWG/RFC 81: Request for Reference Information
J. Bauknight (Ill.) 3 December 1970

I.2

*NWG/RFC 82: Network Meeting Notes
E. Meyer (MAC) 9 December 1970

A.3 A.5 D.1 D.2 D.5 D.6 D.7 E.1 G.1 G.2 H

*NWG/RFC 83: Language - Machine for Data Reconfiguration
R. Anderson et al. (RAND) 18 December 1970

D.3 D.4

*NWG/RFC 84: List of NWG/RFC's 1-80
NIC 23 December 1970

A.4

NWG/RFC 85: Network Working Group Meeting
S. Crocker (UCLA) 28 December 1970

A.2

*NWG/RFC 86: Proposal for a Network Standard Format for a Data Stream to Control Graphics Display
S. Crocker (UCLA) 5 January 1971

D.6

*NWG/RFC 87: Topic for Discussion at the Next Network Working Group Meeting
A. Vezza (MAC) 12 January 1971

A.2 D.6

*NWG/RFC 88: NETRJS - A Third Level Protocol for Remote Job Entry
R. C. Braden, S. M. Wolfe (UCLA) 13 January 1971

D.1 D.2 G.4

*NWG/RFC 89: Some Historic Moments in Networking
B. Metcalfe (MAC, Harvard) 19 January 1971

C.2 D.6 F

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*NWG/RFC 90: CCN as a Network Service Center
R. T. Braden (UCLA) 25 January 1971
G.4

*NWG/RFC 91: A Proposed User-User Protocol
G. Mealy (Harvard) 27 December 1970
D.1 D.2 D.3 D.5 D.7

NWG/RFC 92: (Not Received)

NWG/RFC 93: Initial Connection Protocol
A. McKenzie (BBN) 27 January 1971
D.1

*NWG/RFC 94: Some Thoughts on Network Graphics
E. Harslem, J. Heafner (RAND) 3 February 1971
D.6

*NWG/RFC 95: Distribution of NWG/RFC's Through the NIC
S. Crocker 4 February 1971
A.1

*NWG/RFC 96: An Interactive Network Experiment to Study Modes of Accessing the Network Information Center
D. Watson (SRI-ARC) 12 February 1971
D.2 D.3 D.4 G.2

*NWG/RFC 97: A First Cut at a Proposed TELNET Protocol
J. Melvin, D. Watson (SRI-ARC) 15 February 1971
D.1 D.2 D.3 G.2

*NWG/RFC 98: Logger Protocol Proposal
E. Meyer, T. Skinner (MAC) 11 February 1971
D.1 D.2

*NWG/RFC 99: Network Meeting
P. Karp 22 February 1971
A.2

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*NWG/RFC 100: Categorization and Guide to NWG/RFCs
P. Karp (MITRE) 26 February 1971

A.4

NWG/RFC 101: (Not Received)

*NWG/RFC 102: Output of Host/Host Protocol Glitch Cleaning Committee
S. Crocker 22, 23 February 1971

A.5 B.1 B.2 C.1 C.4 C.5 C.6